TREE VOLUME TABLES FOR FOUR SPECIES GROWN IN PLANTATIONS IN BANGLADESH

SYZYGIUM GRANDE (WT.) WALD (DHAKIJAM)
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ARTOCARPUS CHAPLASHA ROXB. (CHAPALISH)
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GMELINA ARBOREA ROXB. (GAMAR)
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DIPTEROCARPUS TURBINATUS GAERTN.F. (TELI GARJAN)
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CHAPTER 4

TREE VOLUME TABLES FOR *GMELINA ARBOREA* ROXB. (GAMAR)

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INTRODUCTION

Gamar (Gmelina arborea Roxb.) is a moderate sized deciduous tree. Gamar occurs mainly in the natural and plantation forests of Chittagong, Cox's Bazar and Chittagong Hill Tracts. The wood is suitable for cabinet making, pulping, manufacturing of door and window panels, etc. Due to its multiple uses, the need of volume tables was keenly felt. An attempt was, therefore, made to prepare stand volume tables of Gamar for use in Bangladesh.

DATA AND TRACT COVERED

Data for the preparation of these volume tables were collected from the plantation forests of Chittagong, Cox's Bazar, Chittagong Hill Tracts North and Chittagong Hill Tracts South Forest Divisions (Table 4.1) The plantations were raised between 1935 and 1965. Age intervals of the plantations selected for the collection of data were five years and the stem measurements were in five-centimeter diameter classes. The data were collected in imperial units. Diameter at breast height (D), total height (H) and diameter at intervals of 3.05m. (10ft.) from a point 30cm. (1ft.) above the ground level were measured on each tree. Diameters were recorded to the nearest 0.25cm. (0.1in.) and height to the nearest 30cm. (1ft.). The trees were measured up to a top diameter of 20cm. (8in.). The bark-thickness at each measure point was taken in two directions perpendicular to each other and the mean recorded.

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METHOD OF STRATIFICATION AND SELECTION OF SAMPLE TREES FOR MEASUREMENT

Stratification was carried out before the field work was initiated. Beats/Ranges were selected where there were adequate plantations of Gamar. It was decided to measure at least 10 trees, if available, of each of the diameter classes from each Beat/Range. The sample trees of the required diameter classes were then selected in the field as being representative of the crop at the site. A total of 513 trees was measured. Trees were required to have minimum apparent defects. The total number of trees free from such defects was 486, distributed in diameter and height classes as shown in Table 4.2.

COMPILATION

Following collection, the data were sent to Commonwealth Forestry Institute, Oxford, U.K., for processing. Individual trees volume data were recast by computer to provide total volume under-bark (UB) and over-bark (OB) and to top diameter limits of 5, 10, 15 and 20cm. (2, 4, 6 and 8in.) using a graphical method. Over-bark branch wood volume was computed for each tree. Tables also have been developed to read conversion factors for OB to UB volume, volumes for different top diameter limits and branch wood volume, by prediction from diameter, in metric and imperial units.

Function and ratios of the primary variables of total height (H) diameter at breast height (D) and total volume OB (V) were derived for testing in regression analyses. These functions and ratios were D^2, V/D^2, $1/D$, $1/D^2$, Log V, Log D, DH, D^2H, V/D^2H, $1/DH$, $1/D^2H$, H/D^2 and Log H.

Fifteen models were tested after checking the correlation matrices of all primary and derived variables. These models were:

1. $V = a + b\,D$
2. $V = a + b\,D + c\,D^2$
3. $V = a + b\,D^2$
4. $V = a + b\,D^2H$
5. $V = a + b\,D^2 + cH + d\,D^2H$
6. $V = a + b\,D^2 + c\,DH + d\,D^2H$

7. $\text{Log}(V) = a + b \text{ Log}(D)$
8. $\text{Log}(V) = a + b \text{ Log}(D) + c \text{ Log}(H)$
9. $V/D^2 = a + b/D^2 + c/D$
10. $V/D^2 = a + b/D^2$
11. $V/D^2 = a + b/D^2H$
12. $V/D^2 = a + b/D^2 + c\,H/D^2 + d\,H$
13. $V/D^2 = a + b/D^2H + c/H + d/D^2$
14. $V/D^2 = a + b/D^2 + cH/D + d\,H$
15. $V/D^2H = a + b/D^2H + c/H + d/D$

Where a = regression constant and

b, c, d = regression coefficients.

The logarithmic functions are to the base e.

Models were run with imperial data for selecting those of best fit. The equation of best fit was selected on the basis of the following considerations :-

(a) highest correlation coefficient (r)

(b) lowest furnival index (F.I.), which is the standard deviation of the deviations of estimates from actual values.

Regression model 8 was found to be the best fit for a two-way table (F.I. = 2.65) (Table 4.3). Substituting the computed values for a, b and c in the model results in the equation:

$$\text{Log}(V) = 1.63502 \text{ Log}(D) + 0.784847 \text{ Log}(H) - 8.4687076$$ for metric units and

$$\text{Log}(V) = 1.63502 \text{ Log}(D) + 0.784847 \text{ Log}(H) - 4.31289$$ for imperial units

For a one-way table, model 7 was found to be the best fit (F.I. = 3.68) (Table 4.3). Substituting the computed values of a and b in the model results in the eqations:

$$\text{Log}(V) = 2.1472 \text{ Log}(D) - 7.9022697$$ for metric units and

$$\text{Log}(V) = 2.1472 \text{ Log}(D) - 2.33654$$ for imperial units.

Analyses of variance of the regressions are given in Tables 4.4 and 4.5

The equations have been modified for use with girth at breast height (G) by substituting girth for diameter (D) as follows :

$$\text{Log (V)} = 1.63502 \text{ Log (G)} + 0.784847 \text{ Log H} - 6.1845448$$

$$\text{Log (V)} = 2.1472 \text{ Log (G)} - 4.7945$$

for two-way and one-way tables, respectively, in imperial units.

CONVERSION FACTORS

These factors have been developed for conversion of volume OB to volume UB; total volume to volume for various top diameter limits and determination of branch wood volume as a proportion of total wood volume. All the factors have been predicted from D for application to total volume OB in metric or imperial units as appropriate. The following regression models were examined:

1. $y = a + bx$
2. $y = a + b/x$
3. $y = a + bx + cx^2$
4. $y = a + b - e^{-cx}$
5. $y = a\ (1 - e^{-bx})$
6. $y = a + b(x^c)$
7. $y = ax^b$
8. $y = 1/(a + bx)$
9. $y = x/(a + bx)$
10. $y = 1/(a + b\ e^{-cx})$
11. $y = a(1 - e^{-bx})^c$
12. $y = x/(a + bx + cx^2)$

Where, $x = D$, e^x = exponential function and y represents in turn the decimal factors (F) for the following ratios:

i) Total volume UB : Total volume OB

ii) Volume to 2in. or 5cm. top diameter: total volume OB

iii) Volume to 4in. or 10cm. top diameter: Total volume OB

iv) Volume to 6in. or 15cm. top diameter: Total volume OB

v) Volume to 8in. or 20cm. top diameter: Total volume OB

vi) Branch wood volume: Total volume OB.

The factors were computed in metric as well as imperial units. The following equations of best fit were obtained.

Equations of the conversion factors:

Volume UB (Model 3) -

$F = 0.74986 + 0.00317244D - 0.0000243195486D^2$ (Metric)

$F = 0.74986 + 0.008058D - 0.0001569D^2$ (Imperial)

Volume upto 2in./5cm. top diameter (Model 10) -

$F = 1/(1.000009 + 0.932918\ e^{-0.189399D})$ (Metric)

$F = 1/(1.000009 + 0.932918\ e^{-0.48107D})$ (Imperial)

Volume upto 4in./10cm. top diameter (Model 5) -

$F = 0.9933706 - 2.776834\ e^{-0.141157756D})$ (Metric)

$F = 0.9933706 - 2.776834\ e^{-0.358541D})$ (Imperial)

Volume upto 8in./20cm. top diameter (Model 11) -

$F = 0.9160558\ (1 - e^{-0.2048035D})^{186.502}$ (Metric)

$F = 0.9160558\ (1 - e^{-0.5202009D})^{186.502}$ (Imperial)

Volume of branch wood (Model 5) -

$F = 1/(11.14767 + 51987.78\ e^{-0.76215354D})$ (Metric)

$F = 1/(11.14767 + 51987.78\ e^{-1.93587D})$ (Imperial

where F is the decimal factor to be multiplied with the volume OB to calculate the required volume.

VOLUME TABLES

Volume can be calculated from the one-variable or two-variable regression equations, as appropriate, using an electronic calculator. It can also be found from the tables, if less precision is acceptable. The tables have been constructed in metric as well as imperial units as follows :

Metric Units

a. One-way table -

Provides total volume OB in cu.m. with D given in 2cm. intervals from 10cm. to 120cm. (Table 4.6).

b. Two-way table -

This table provides total volume OB in cu.m. with D given in 2cm. intervals from 10cm. to 120cm. and H given in 2m. intervals from 3m. to 39m. (Table 4.7).

c. Conversion factors

These decimal factors are to be applied to total volume OB to obtain total volume UB and volumes to 5, 10, 15 and 20cm. top diameter limits and branch wood, as appropriate. These conversion factors are provided against D from 5cm. to 75cm. in 1cm. intervals (Table 4.8)

Imperial Units

a. One-way tables -

i) Provides total volume OB cu.ft. with D given in inches, from 3in. to 52in. Confidence limits at the 95% level also have been provided against D from 3in. to 48in. at 5in. intervals (Table 4.9).

ii) Provides total volume OB in cu.ft. with G given in inches, from 10in. to 150in. at 2in. intervals (Table 4.10).

b. Two-way tables -

i) Provides total volume OB in cu.ft. with D given in inches, from 3in. to 52in. and H given in feet, from 10ft. to 120ft. at 5ft. intervals. Confidence limits at the 95% level are also provided against D from 3in. to 48in. at 5in. intervals (Table 4.11).

ii) Provides total volume OB in cu.ft. with G given in inches from 10in. to 150in. at 2in. intervals and H given in feet from 10ft. to 120ft. at 5ft. intervals (Table 4.12).

c. Conversion factors -

These decimal factors are to be applied to total volume OB to determine total volume UB and volumes to 2, 4, 6 and 8in. top diameter limits and branch wood volume. The conversion factors are provided against D given in inches from 2in. to 50in. in 1in. intervals (Table 4.13).

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